Energy Biosciences Institute

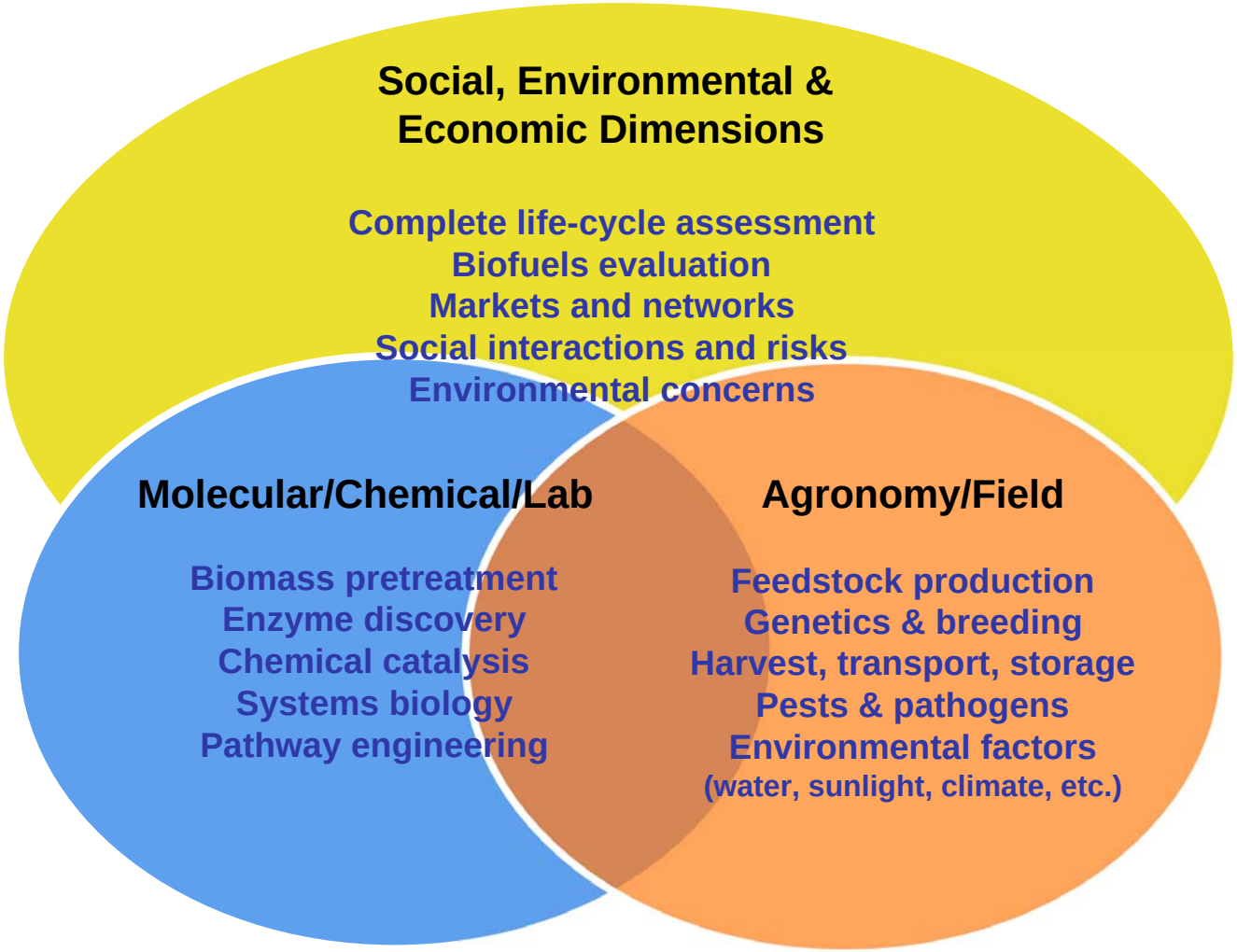
EBI Research Program
CEC Presentation
1/13/2009

Dr. Susan Jenkins, EBI Assistant Director

The Energy Bioscience Institute:

- Partnership between UCB, UIUC, LBNL & BP
- BP has committed $500M over 10 years
- Goals include:
  - **total system solutions to the production of biofuels that are cost effective and sustainable**
  - development of improved biotechnologies for energy applications
  - education of scientists and engineers across the relevant disciplines

EBI research focus



Scientific programs areas

- Agronomy & feedstocks
- Pretreatment & depolymerization
- Biofuels production
- Environmental, social & economic dimensions

Agronomy & feedstocks

Development of dedicated energy crops

- **Studies on obtainable biomass**
  - 320 acre Energy Farm
  - comparative trials of *Miscanthus*, switchgrass, and various native prairie grasses at sites around North America
  - establishing collaborations with sites in Brazil for similar trials with sorghum and sugar cane
  - collaborations with experts in plant systematics to help identify other potentially useful plant species
- **Woody species**
- **Salt-tolerant species**
- **Pests and pathogens**
  - insects, nematodes, fungi, bacteria, viruses
- **Genetic diversity**
  - comparative genomic studies on *Miscanthus* and sugarcane
- **Breeding barriers**
  - self-incompatibility
- **Grass transformation technologies**
  - increase efficiency

Agronomy & feedstocks

Transport, harvesting and storage

- **Pre-harvest Energy Crop Monitoring**
- **Harvesting of Energy Crops**
- **Transportation of Biomass**
- **Storage of Biomass**
- **Systems Informatics and Analysis**

Pretreatment & depolymerization

Imaging

- **Visualizing lignocellulose**
  - Raman spectroscopy
  - EM tomography
  - Electron microscopy
  - Atomic force microscopy

Pretreatment technology

- **Ionic liquids**
- **Delignification and hemicellulose solublization**
- **Identification of inhibitory products**

Pretreatment & depolymerization

Bioprospecting for enzymes and organisms

- **Cellulase assay development**
- **Cellulases from extreme environments**
- **Directed evolution of cellulase**
- **Designer cellulosomes**
- **Thermophilic microorganisms**
- **Microbes from cow rumen**
- **Microbes from grass-feeding termites**

Pretreatment & depolymerization

Biological approaches to lignin depolymerization

- **Grass-degrading fungi**
- ***Neurospora* degradation of *Miscanthus***
- **Bacterial degradation of lignin**
- **Lignin peroxidase studies**

Chemical approaches to lignin and cellulose depolymerization

- **Biomass conversion with synthetic catalysts**
- **Alternate fuel routes via lignin**
- **Synthetic organometallic catalysts for lignin cleavage**

Biofuels production

Current generation biofuels

- **Novel membranes for dehydration of ethanol**

Next generation biodiesel

- **Assessment study on algal biodiesel production**
- **Non-thermal chemical conversion**
- **Engineering microbes for bioconversion**
- **Chemical conversion of biomass to diesel-compatible fuels**

Bioconversion of biomass to fuels

- **Alleviating product toxicity in biofuel production**
  - two-phase partitioning
  - engineering enhanced tolerance

Biofuels production

Systems biology

- **Determining genetic mediators of optimal fuel production in fungi**

Engineering yeast for sugar utilization

- **Xylose utilization**
- **Engineering novel pentose utilization pathways and transporters**
- **Metabolic flux analysis for sugar utilization**

Metabolic regulation in bacteria

- **Characterization of multiple-sugar utilization**

Environmental, social and economic dimensions

Environment

- **GHG measurements (energy farm facility)**
- **Water availability and quality**
- **Biodiversity impacts**
- **Nitrogen utilization**

Life cycle assessment

- **Development and assessment of methods for:**
  - biomass production
  - biofuels production
  - transport and storage
  - air emissions and air quality
  - health and ecosystems impacts
  - economic analysis

Environmental, social and economic dimensions

Land use

- **Indirect land use**
  - food versus fuel
  - land conversion
- **Establishment of dedicated energy crops**
  - optimal locations
  - proximity to refineries
  - optimal feedstock mix
- **Determining marginal and abandoned lands**

Food and fuel market impacts

- **Assessing competitiveness with Brazil and potential trade effects**
- **Impact of biofuels on food and energy**
- **Modeling global oil prices**
- **Assessing and modeling carbon/GHG emissions cost**
- **Developing trade scenarios for corn and cellulosic ethanol (CGE model)**

Environmental, social and economic dimensions

Social and Policy Aspects

- **Technology innovation and adoption**
- **Intellectual property rights**
- **Food security**
- **Potential for global conflicts with shift toward biofuels**
- **Global perspective on economic and political control**
- **Domestic and international regulations and laws**

Workshops supported (wholly or in part) by EBI

- Bioenergy Feedstocks Symposium (2008, 2009)
- Berkeley Energy and Resources Collaborative Symposium (2008, 2009)
- Greenhouse Gas Emissions from Biofuels (2008)
- Pan American Congress on Plants and Bioenergy (2008)
- Transition to a Bioeconomy: Risk, Infrastructure and Industry Evolution (2008)
- Measuring and Modeling the Life Cycle GHG Impacts of Transportation Fuels (2008)
- Biofuels and Sustainability (2008)
- Linking Biophysical and Economic Models of Biofuel Production and Environmental Impacts (2008)
- Bioenergy Crop Modeling and Land Use (2008)
- Biologically-Enhanced Carbon Sequestration (2007)
- Research Priorities in Microbially-Enhanced Hydrocarbon Recovery (2007)

Education and outreach

- **Provide investigators access to UCB, UIUC and LBL intellectual resources as visiting scholars**
- **Educate the next generation of energy scientists**
  - Postdoctoral
  - Ph.D.
  - B.S.
- **Educate the public**
  - general public
  - public policy students
  - policy makers
  - K-12
- **Provide extension activities targeting the agricultural community**

Program, project and workshop summaries
available online at

http://energybiosciencesinstitute.org

or by request

ebi@berkeley.edu

Questions/comments/discussion

CEC - EBI Joint opportunites for biofuels

- Improved feedstocks specific for regions
- Improved processes for lignocellulosic biofuel production
- Determining optimal land use for bioenergy cropping with minimal impact on food supply, environmental sustainability and water resources
- Mapping and model simulations of bioenergy crop scenarios in California

  Improved agricultural practices